Center Innovation Fund: LaRC CIF

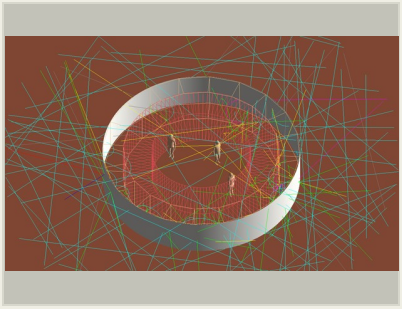
Hybrid Active-Passive Radiation Shielding System

Completed Technology Project (2014 - 2015)

Project Introduction

A radiation shielding system is proposed that integrates active magnetic fields with passive shielding materials. The objective is to increase the shielding effectiveness against galactic cosmic radiation (GCR). Active shielding alone requires high power, and passive shielding alone requires high mass. The hybrid shield has the potential to address both these issues.

The problem is that we have a vision of landing humans on Mars in the 2030s, but we do not yet know how to protect them from the space radiation. We are developing radiation shielding based on integrating active magnetic fields with passive shielding materials to increase the shielding effectiveness against galactic cosmic radiation (GCR). Active shielding alone requires high power, and passive shielding alone requires high mass. The hybrid shield has the potential to address both these issues of power and mass. The goal is to develop an optimized system of hybrid active-passive radiation shielding. Currently, there is no clear-cut solution to shielding humans from GCR during long duration space travel (more than 6 months from Earth to Mars, one way) and during planetary stays for exploration. Two different approaches exist: (1) choose the right passive materials combinations to slow down the GCR and the secondaries arising out of the interactions of the GCR with intervening matter; or (2) use active magnetic fields to deflect the GCR. These two approaches have limitations, necessitating a new approach like the proposed hybrid shielding. In the new hybrid shield approach, the GCR is bent by the magnetic field, and instead of traveling in a straight path it bends and takes a longer path, thus reducing the required mass of the passive shield component. The passive shielding materials reduce the speed of the incoming particles and thereby reduce the required magnetic field intensity and therefore reduce the power requirements of the active shield component. The combined effects of increased path length and reduced particle speed are two critical controlling factors for realizing improved shielding effectiveness. Preliminary results were obtained by using the Geant (Geometry and Tracking) 4 physics code in two-dimensional and three-dimensional radial simulations. The results show reduction in dose equivalent to human phantoms. Viable radiation shielding against GCR can be an enabler for human exploration of space. The success will have a huge impact on human exploration and operations missions in terms of the protection of humans for space exploration. It will be measured by the increased number of safe days in space. The systematic approach using the best and validated simulation tools to develop and down select viable concepts mitigates the risks of this approach. The effort aims to develop a series of simulations providing for analyses of shielding systems in sufficiently realistic detail to enable comprehensive understanding of the benefits provided and the relative merits of various optimizations. Given that the proposed simulation engine uses a Monte



Hybrid active-passive shield stops more radiation than passive shield alone.

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- Carlo approach, it is generally best initially to go with the simplest configuration that meets requirements, so stable statistical results can be achieved more easily and with less computational time. In later steps of the optimization, it is necessary to invest the required time to ensure that the physical processes are accurately implemented, so all the important features are correctly modeled in order to get accurate and meaningful simulations. The potential payoff is high because the resulting hybrid active-passive shield concept could enable long duration space travel and space exploration for humans. This approach might also be useful for developing radiation protection for ion beam therapies on Earth. The progress will be measured by comparing the dose equivalent results of the simulated hybrid active-passive shields with the simulated equivalent active or passive shields. The simulations will include GCR and also high-energy mono-species, mono-energetic beams (neutron, proton, light ion, and heavy ion).

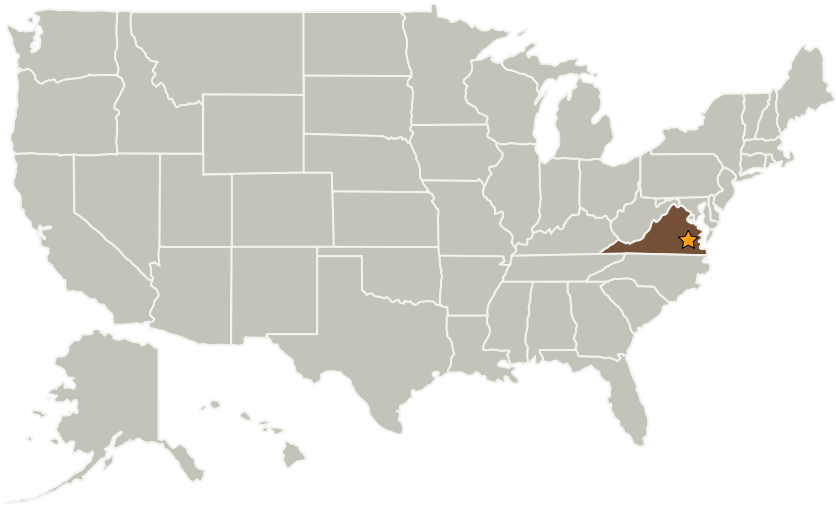
Anticipated Benefits

Increased safety for humans on NASA funded missions

Increased number of safe days for NASA unfunded and planned missions

Enabler for human missions

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Innovation Fund: LaRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

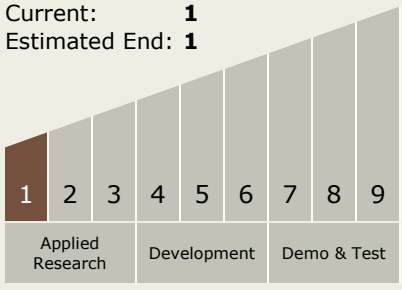
Julie A Williams-byrd

Principal Investigator:

Sheila A Thibeault

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **1**



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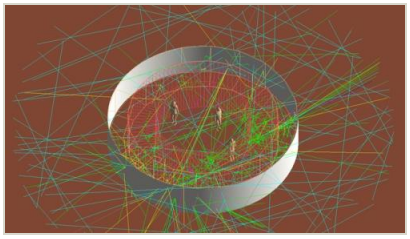
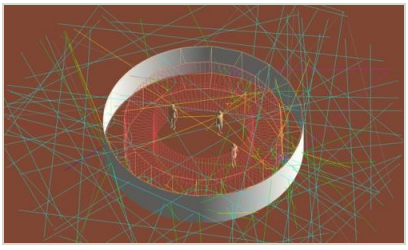
Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia
Analytical Services & Materials, Inc.	Supporting Organization	Industry Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB)	Hampton, Virginia
National Institute of Aerospace	Supporting Organization	Academia	Hampton, Virginia

Primary U.S. Work Locations
Virginia

Images



Hybrid Active-Passive Radiation Shielding System
Passive shield only
(https://techport.nasa.gov/image/18390)



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(https://techport.nasa.gov/image/18391)

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.5 Radiation
    - TX06.5.3 Protection Systems